Numerical simulations on single mask conical GEMs

Tue, 28th April 2009 – CERN

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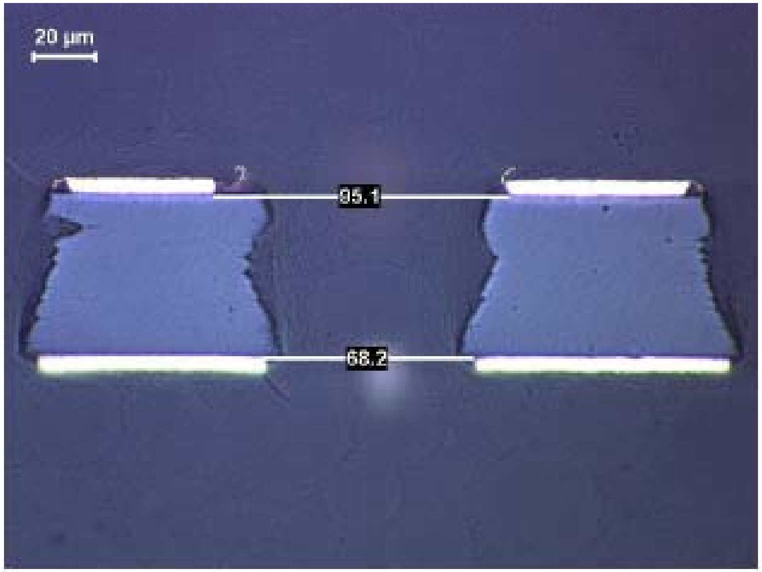
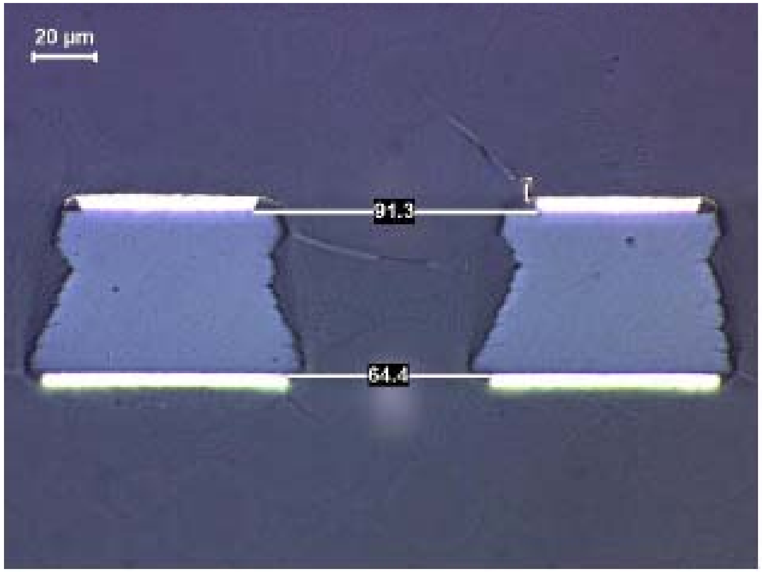
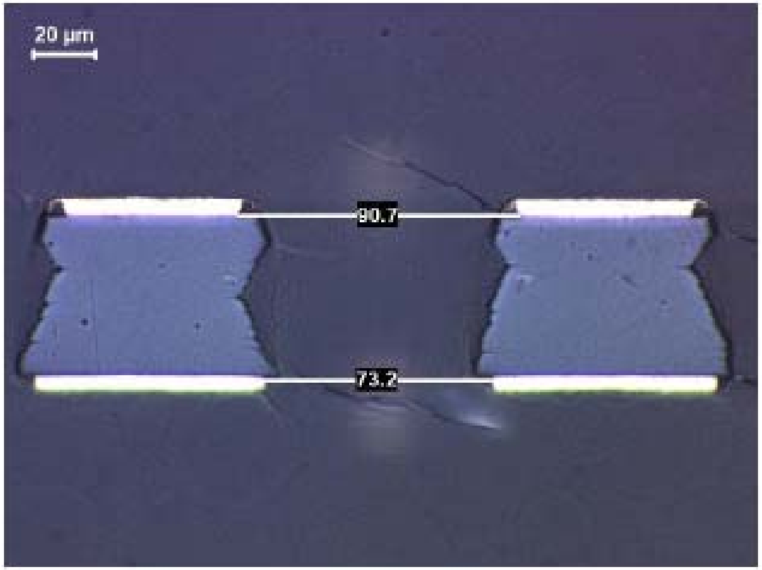
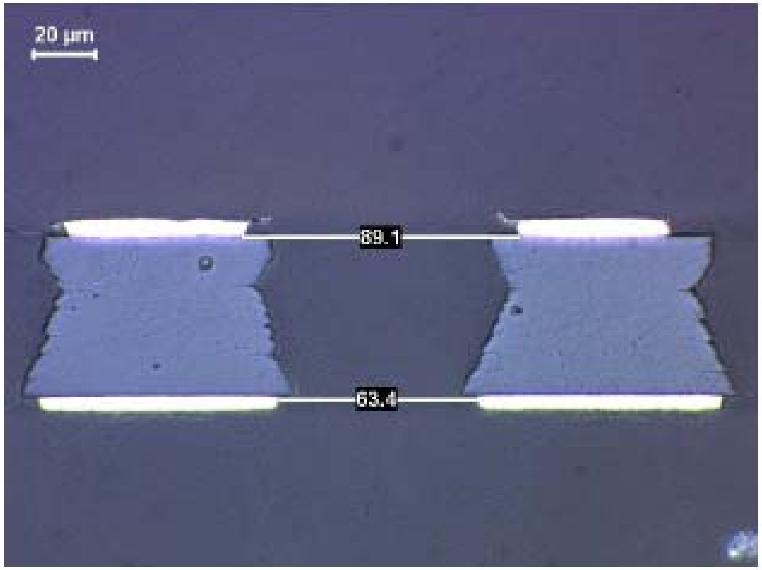
Cross-section pictures of the gold-plated GEMs









Why simulations on conical GEMs?

➢ large area GEMs

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single mask lithographic process is used for the production, leading to conical GEMs

➢ *what are the properties of the GEM detectors obtained with single mask lithographic technique?*

➢ *how do these properties depend on the geometry?*

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✓ spatial uniformity
✓ time stability
✓ electron transparency
✓ discharge probability
✓ maximum achievable gain

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✓ field shape
✓ electron transparency
✓ avalanche shape
✓ charging up properties

Simulations: basics

Simulation

- *ANSYS PACKAGE*

Ansys is used to define:

1) the geometry;
2) the material properties;
3) the electrodes voltage;
4) the e.m. boundary conditions;

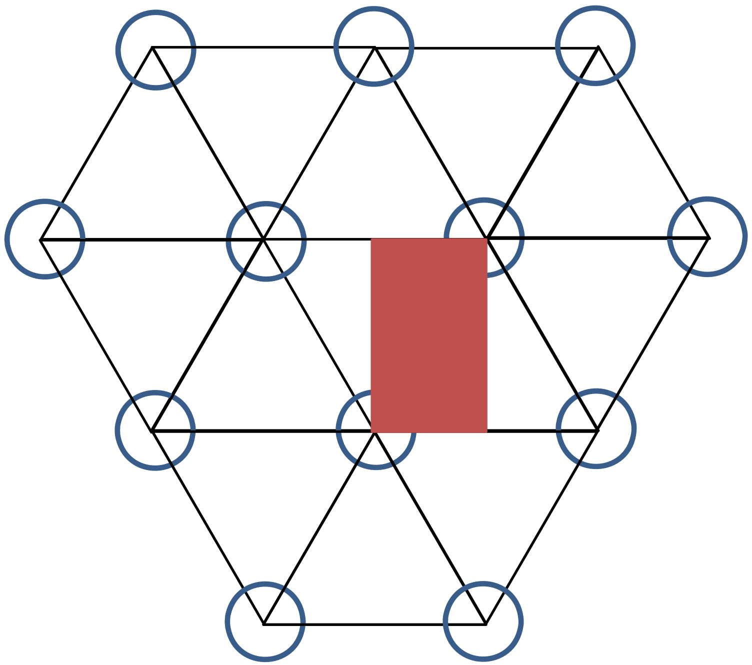
and to solve the e.m. equations with a finite elements analysis method

- *GARFIELD PACKAGE*

Garfield is used to:

1) read the Ansys fieldmaps;
2) define the gas properties;
3) simulate the behavior of electrons in the gas

ANSYS (1): definition of the geometric and electrostatic properties



Geometric properties:

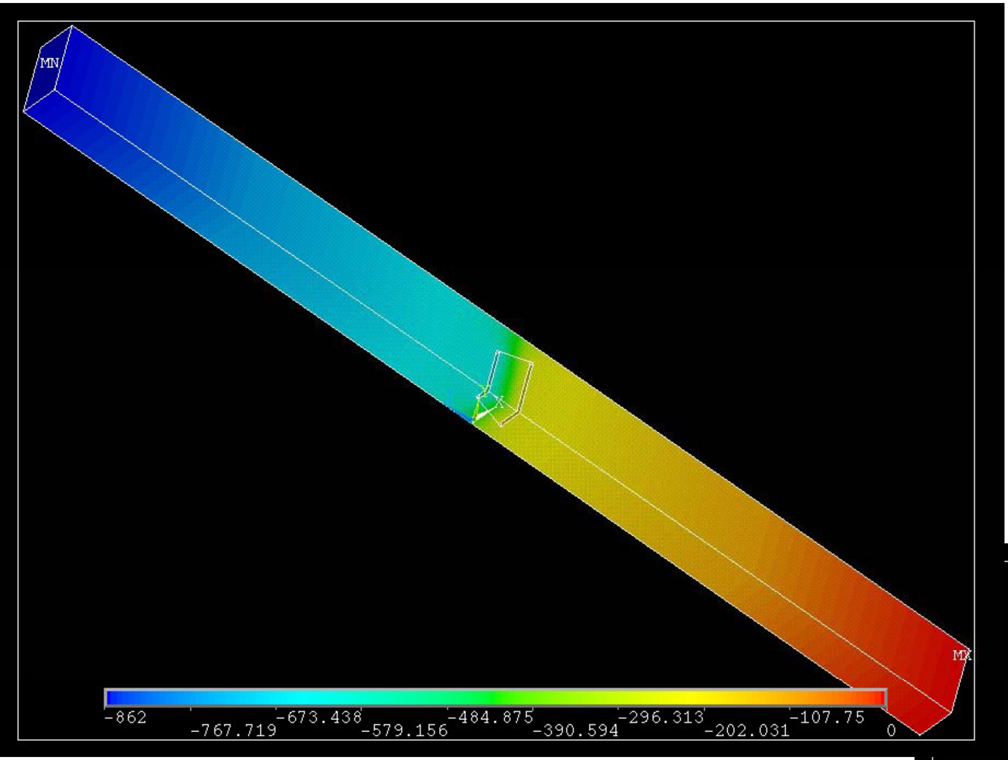
- kapton thickness = 50 μm
- copper thickness = 5 μm
- drift gap thickness = 770 μm
- induction gap thickness = 770 μm
- holes pitch = 140 μm
- hole smaller diameter = 55 μm
- hole larger diameter = 55 μm → 95 μm

Electrostatic properties:

- drift field = 3 kV/cm
- GEM voltage = 400 V
- induction field = 3 kV/cm

✓ in order to speed up the simulation, only the elementary cell has been considered, as shown in the scheme

ANSYS (2): meshing options and field solution



- ➢ ANSYS automatic mesher set to produce an high precision mesh

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✓ good cell description

- ➢ further low–level manual mesh refinement in all the volume

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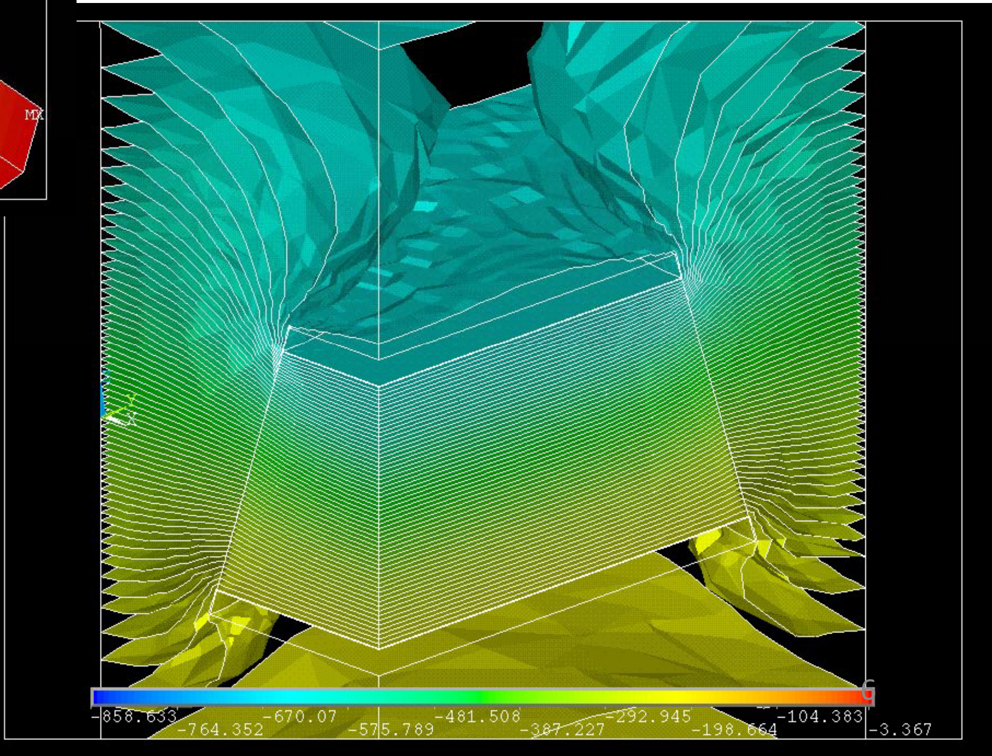
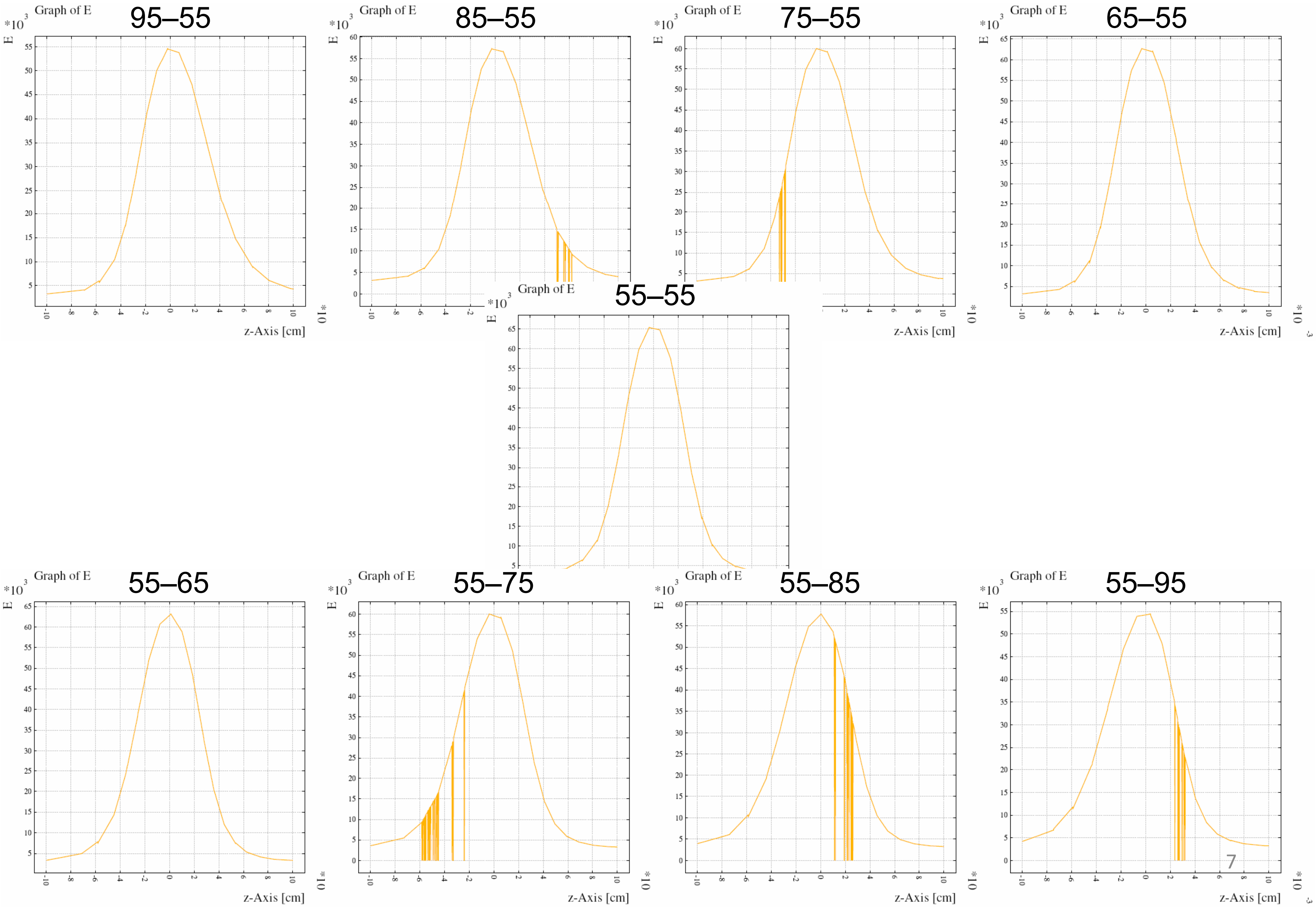
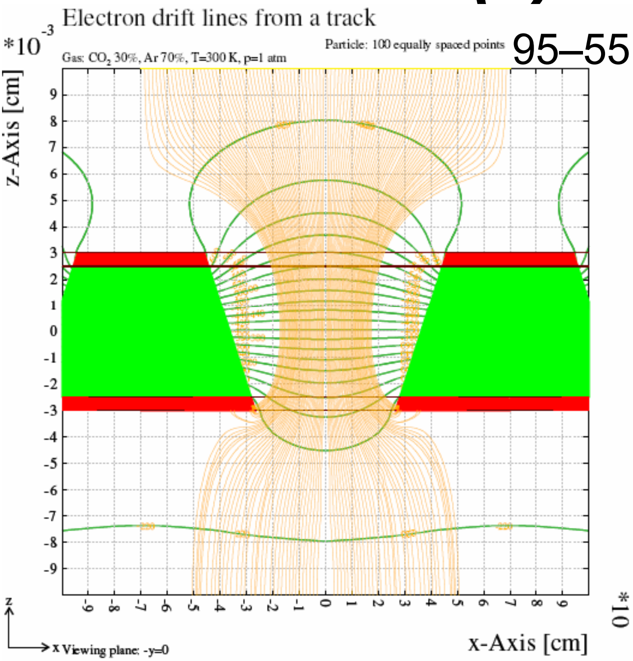
✓ good and homogeneous mesh with reasonable field map size (≈ 20K tetrahedra, 3MB)

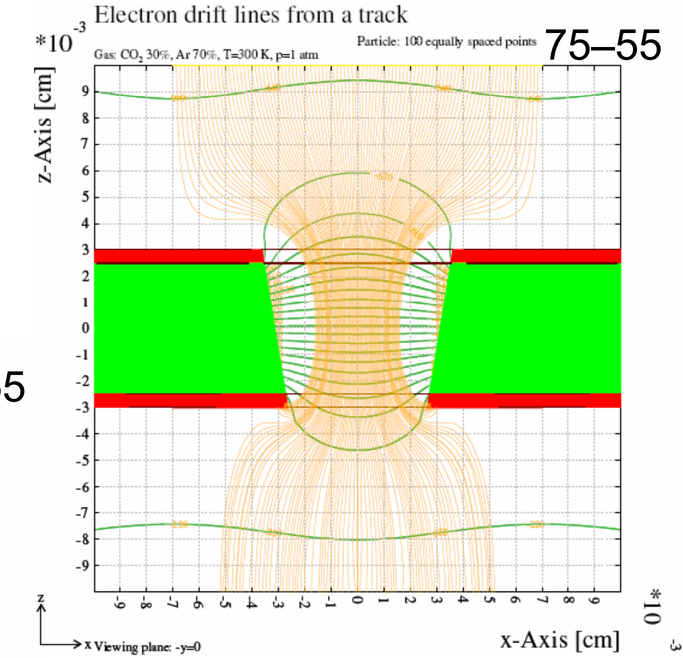


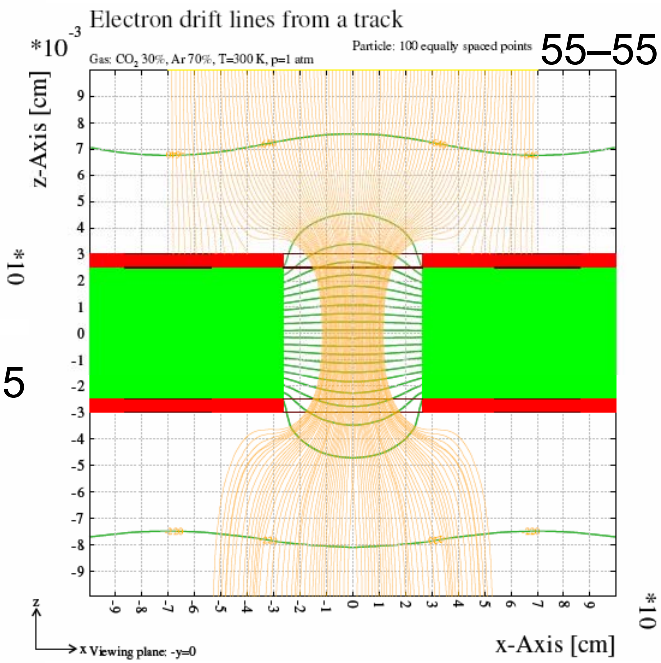
GARFIELD (1): field strength on the hole axis

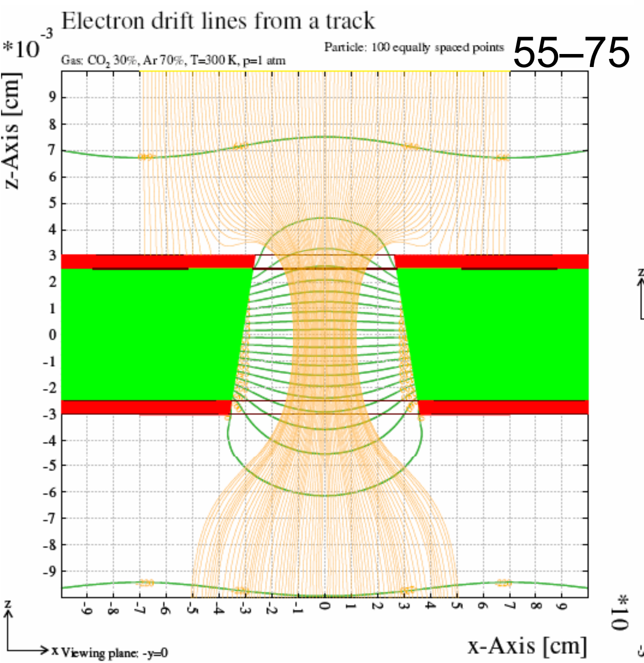


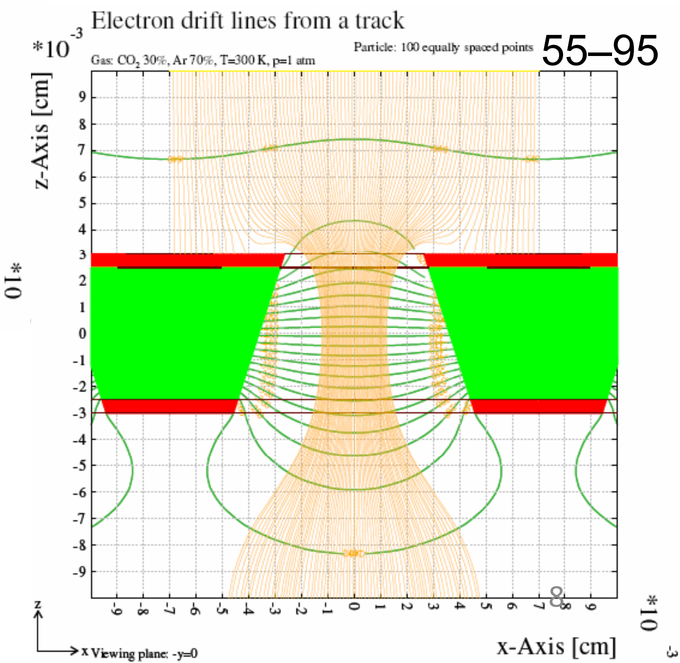
GARFIELD (2): electrons drift lines on the hole section



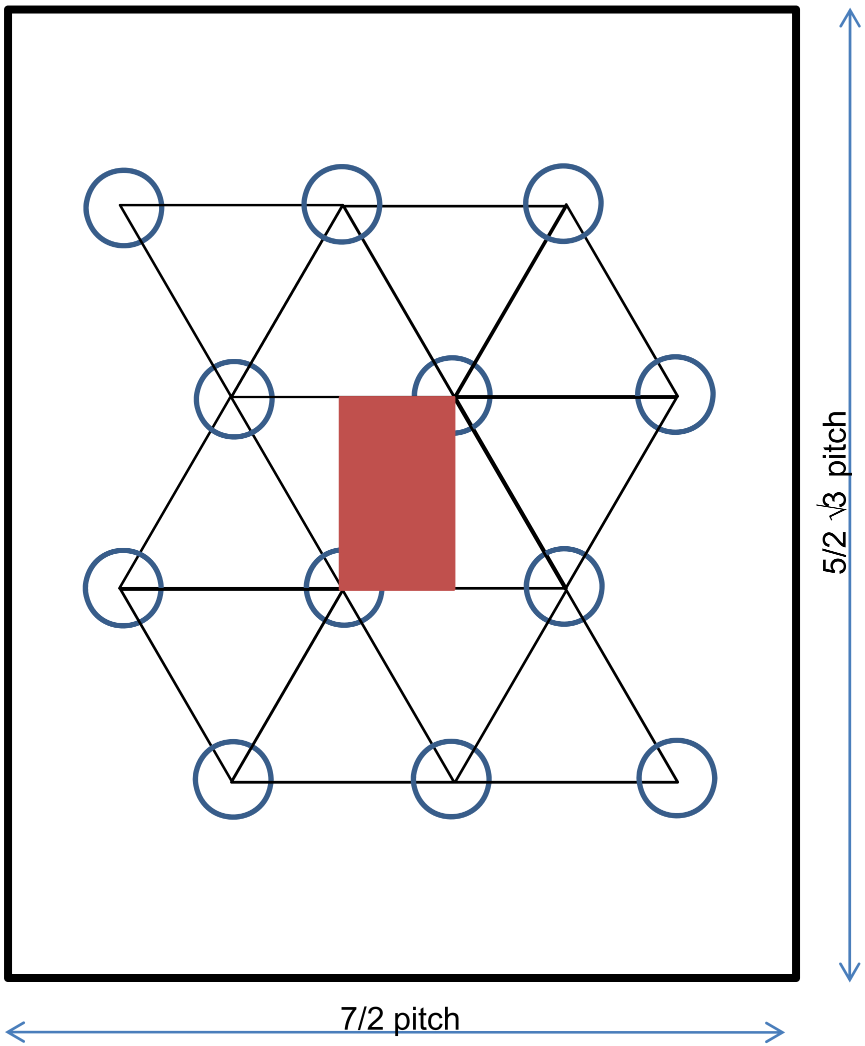








GARFIELD (3): transparency microscopic study



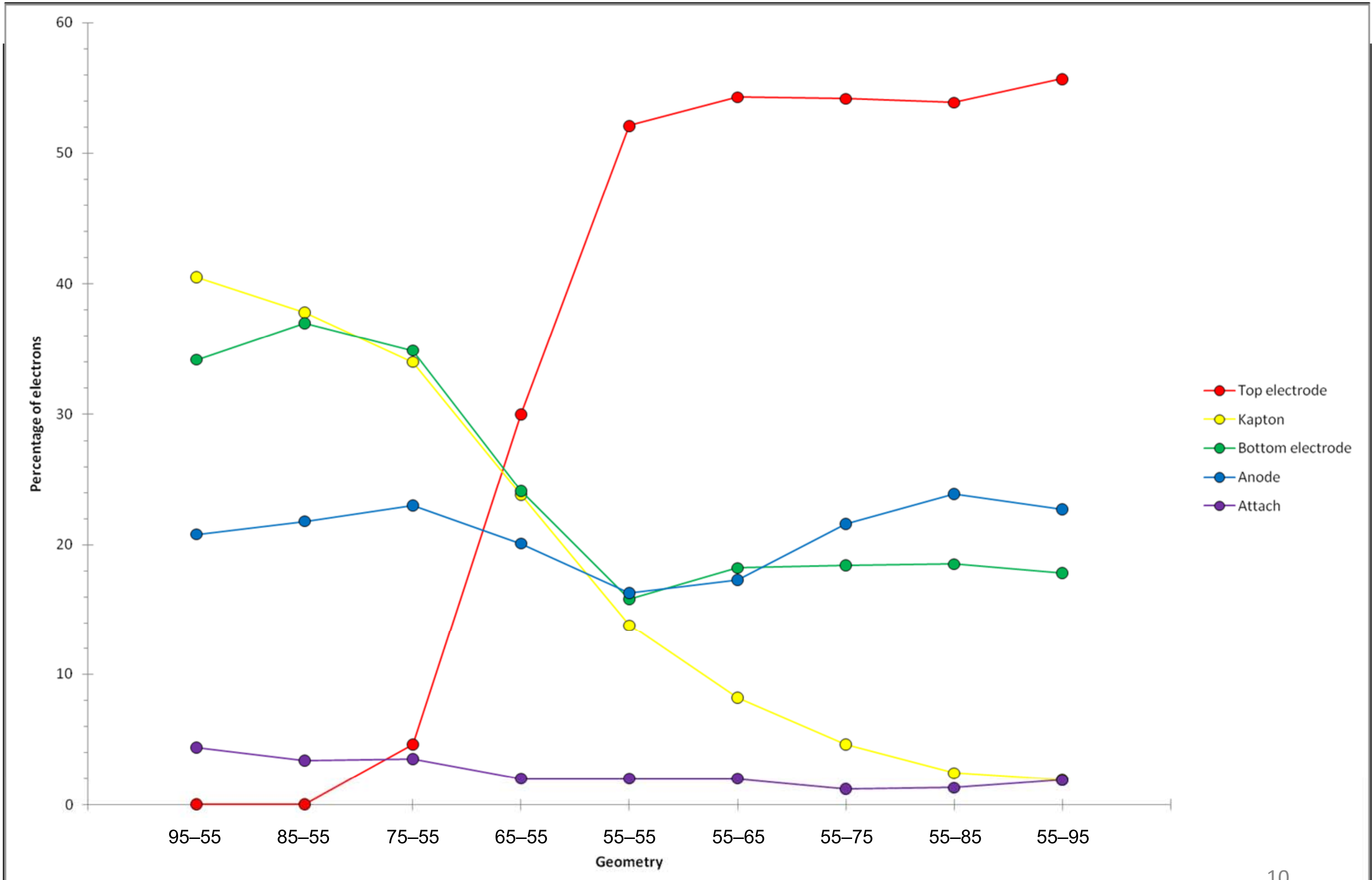
1) random $x_{start} \in [0; pitch/2]$
2) random $y_{start} \in [0; \sqrt{3}\ pitch/2]$
3) $z_{start} = 100\ \mu m$
4) $E_{start} = 0.1\ eV$
5) random direction of $\mathbf{p}_{\mathbf{start}}$

- the electron is traced using a microscopic technique which step is the free path
- at each step a collision is simulated
- the result of the drift is recorded, together with x_{end}, y_{end} and z_{end}

5 possible scenarios:

- ✓ hit top electrode
- ✓ hit kapton
- ✓ hit bottom electrode
- ✓ hit anode
- ✓ attached to a gas molecule

GARFIELD (4): transparency study results



Conclusions and outlooks

- ➢ the overall electron transparency is about 20% and it depends only slightly on the hole geometry

- ➢ the percentage of electrons ending up on each electrode and on the kapton layer varies from one geometry to another → different detector behavior

- ✓ the statistics is quite poor (1000 electrons for each geometry) → higher statistics will help to improve precision

- ✓ the diffusion was accurately modeled, but no avalanche was simulated

- ✓ the kapton charging up is not taken into account → need to implement the charging up in order to compare the results with experimental data